

Toward a better understanding of hospital occupancy rates

by P. Joseph Phillip, Ross Mullner, and Steven Andes

This article starts out with the premise that a "uniform occupancy rate" for hospitals is not a meaningful concept because the ability of individual hospitals to maintain a certain occupancy rate consistent with a specified "protection level" depends upon several factors. These factors include hospital size, the number of nonsubstitutable patient facilities, the percent of nonurgent (elective) beds, the number of hospitals serving an area, and the relative variation (fluctuation) in the demand for services faced by the hospital. A regression analysis with observed, overall occupancy rate as the dependent variable, and

measures that attempt to represent the factors just mentioned as independent variables, tends to substantiate this line of reasoning. However, inasmuch as the status of the independent variables (that is, whether or not they can be regarded as justifiable or uncontrollable) depends largely on the circumstances of each case, the regression model cannot be used as a standard-setting tool. Nonetheless, it offers valuable guidelines for hospital management, planners, and regulators in such areas of decisionmaking as the location and size of hospitals, and acceptable occupancy standards.

Introduction

The "low" occupancy rate of hospitals has been—and continues to be—a subject of debate. It is alleged that, on a national basis, the average occupancy rate of hospitals is lower than it ought to be, and the resulting idle capacity contributes, in an important way, to the escalating cost of hospital care (Shain and Roemer, 1959; McClure, 1976). The debate gained national headlines in 1976 with the publication of the report: *Controlling the Supply of Hospital Beds, A Policy Statement*, (Institute of Medicine, 1976).

Because the average occupancy rate of community (that is, non-Federal, short-term general) hospitals is about 76 percent, there is a general disposition to jump to the conclusion that idle capacity is rampant in the hospital industry—if we apply traditional standards germane to most industries. But the hospital industry is not *any* industry. Indeed, it is the premise in this article that the hospital industry has several distinctive attributes, and what constitutes an "optimum" or "socially desirable" utilization rate of hospital facilities depends on a complex set of factors. Systematic evaluation and recognition of these factors are overdue, especially in view of the fact that there have been some recent attempts to set minimum capacity utilization standards. The National Guidelines for Health Planning issued by the Department of Health and Human Services (1977), for example, set an 80-percent occupancy rate as the minimum standard for community hospitals.¹ More recently, the Brown Administration in California formulated a plan

to link Medi-Cal hospital inpatient reimbursement to minimum occupancy standards. According to this plan, those hospitals with occupancy rates that fall below 55 percent would be denied fixed costs (estimated to average 41 percent of total cost) associated with "unneeded" beds. During the fiscal year starting July 1981, some 208 out of California's 506 community hospitals were affected by this standard; and what is more significant in terms of the findings reported later in this article, the severity of penalty tends to be inversely related to hospital size. See Vaida (1981) for a listing of hospitals affected, estimated penalties, and so on.

Capacity utilization defined

Although capacity is generally calculated on the basis of full-time operation of a firm, different industries adopt qualifications to suit their distinct modus operandi—the preferred rate of output plus a normal safety margin, the practical maximum rate barring enormous repair and maintenance costs, the minimum-average-cost rate, and so on (de Leeuw and Grimm, 1978). In the hospital industry, capacity is traditionally defined in terms of bed complement. But the industry counts beds in more than one way: (1) beds set up and staffed, and (2) licensed beds. Licensed beds are defined as the maximum number of beds approved by the licensing agency, and are not necessarily existent beds. In fact, our analysis of California hospitals shows that in about one-half of the cases, the excess of licensed beds over beds set up and staffed represents "phantom" beds. Traditionally, a count of beds set up and staffed is obtained in two ways: (1) year-end beds, and (2) statistical beds, which is a sort of weighted average of beds. For example, if a hospital started out with 100 beds in January 1980, and added 40 beds in October 1980, statistical beds for the year 1980 would be $100(9/12) + 140(3/12) = 110$, whereas year-end beds would, of course, be 140.

¹It should be mentioned, in all fairness, that the Guidelines permit relaxation in two situations: hospitals serving areas with seasonal population fluctuations, and small hospitals serving areas with very low population density.

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For the analysis reported in this article, capacity is defined as statistical beds set up and staffed, 365 days a year, 24 hours a day.

Special significance of idle capacity

It is well known that the delivery of hospital care has several unique features. Let us consider two that are most germane to the present discussion.

First, in the delivery of hospital care, the time factor is of such overriding importance that it precludes scheduling in all but those instances involving non-emergency or elective cases. Now, consider a hospital operating at 80 percent occupancy rate, or, what is the same thing, an idle capacity of 20 percent. There is a real sense in which this "safety margin" to deal with fluctuations in the arrival of patients may be considered productive. Idle capacity eliminates or minimizes the cost of delaying or denying admission. These costs include the greater pain and suffering, increased probability of death or permanent disability, and greater curative costs arising from delayed treatment. The following excerpt brings home, forcefully, the likely consequences of indiscriminate cutbacks in idle capacity:

In a news conference by nine members at the Committee headquarters, 386 Park Avenue South, Dr. Ira Helfand of North Central Bronx Hospital said a heart-attack patient waited last Friday from 2:15 a.m. to 2:30 p.m. for admission to the hospital's intensive-care unit He told of an 85-year-old man being transferred at 4 o'clock one morning to a Queen's hospital to free a bed. (*New York Times*, 1980).

Second, hospital care must be consumed "in person" so that swift access to hospital facilities by the patient takes on a degree of importance which sometimes supersedes, or at least serves to temper such considerations as demand steadiness and economies of scale—critical factors that enter into managerial decisions concerning the location and size of firms in most industries. We intend to show, presently, that subordinating these considerations in the interest of access—an admittedly social welfare criterion—impairs the ability of hospitals to maintain higher occupancy levels.

Factors causing variations in occupancy rates

A cursory examination of the hospital industry shows that there are broad variations in the occupancy rates maintained by individual hospitals. Without making value judgments as to what ought to be the occupancy rates, it is insightful to examine what causes such wide variations across hospital sizes and regions.

Hospital size

Consider Table 1 which displays the occupancy rates of community hospitals by bed-size class.

Table 1
Average occupancy rate of community hospitals,
by bed-size class: 1981

Bed-size class	Average occupancy rate	
	Percent	
6-24 beds	46.2	
25-49 beds	53.0	
50-99 beds	64.7	
100-199 beds	71.8	
200-299 beds	77.8	
300-399 beds	79.8	
400-499 beds	81.7	
500 beds or more	82.5	

SOURCE: American Hospital Association. *Hospital Statistics* (1982 ed.), Chicago, Table 5A.

Successively larger hospitals have successively higher average occupancy rates. This may be explained by the fact that the larger the hospital, the greater its ability to maintain a higher level of occupancy rate consistent with a given protection level.² The statistical explanation runs as follows: Assuming that patient arrivals are approximately Poisson-distributed (Blumberg, 1961; Shonick, 1970; and Hancock, et al, 1978), the larger the average daily census (ADC), the smaller the coefficient of variation, that is, the variation in relation to the average.³ To bring the impact of hospital size on occupancy rate into clearer relief, Table 2 displays the occupancy rates consistent with protection levels of 90 percent, 95 percent, and 98 percent.

Table 2
Occupancy rates consistent with three
protection levels

Bed size	Protection level		
	90 days in 100	95 days in 100	98 days in 100
	Percent		
10 beds	60	50	45
15 beds	67	60	53
25 beds	72	68	61
50 beds	84	78	72
100 beds	87	84	80
500 beds	95	93	91
1,000 beds	96	95	94

²Protection level refers to the ability of the hospital to admit a patient instantly. Traditionally, protection level is stated in probabilistic terms as, for example, 98 percent protection, implying that all arrivals could be admitted instantly 98 percent of the time (or "turnaway" or "overfill" rate occurs 2 percent of the time).

³A property of the Poisson distribution is that the mean is equal to the variance. Now, consider two hospitals with means (ADC's) of 10 and 1,000. The coefficient of variation of the first hospital is: Standard Deviation ÷ Mean = $\sqrt{10}/10 = 0.32$, whereas that of the latter is only $\sqrt{1000}/1000 = 0.032$.

Table 3
Community hospitals reporting specialized facilities: 1978

Facility	Bed size							
	6-24	25-49	50-99	100-199	200-299	300-399	400-499	500 or more
	Percent							
Medical-surgical (adult)	94.8	97.1	96.4	96.8	98.6	98.5	100.00	99.3
Medical-surgical (pediatric)	13.7	24.1	37.4	59.1	78.0	85.1	84.7	85.8
Pediatric intensive care	0.5	0.4	0.9	1.8	2.1	6.7	12.3	28.7
Neonatal intensive care	—	0.2	0.8	4.5	10.0	18.6	29.4	51.5
Cardiac intensive care	10.4	14.5	15.5	25.7	50.4	63.4	81.3	76.9
Mixed intensive care	10.8	27.3	53.9	80.9	93.7	97.9	97.0	97.7
Burn care	0.5	0.7	0.4	0.9	3.0	5.2	7.7	16.2
Obstetric	36.3	41.4	57.4	62.1	73.1	83.0	88.1	90.8
Neonatal intermediate care	0.5	0.8	1.3	2.1	4.6	6.4	12.8	12.0
Self-care	0.9	1.0	2.4	14.0	30.3	49.5	63.0	81.5
Long-term skilled nursing	3.8	5.7	11.9	12.1	10.9	10.3	8.9	12.9
Other long-term care	0.9	2.3	4.6	4.7	3.1	2.3	1.3	4.0
Psychiatric	0.9	1.0	2.4	14.0	30.3	49.5	63.0	81.5
Mental retardation	—	—	0.1	—	0.1	—	—	0.7
Alcoholism/chemical dependency	0.9	0.1	1.2	4.2	6.2	10.3	14.5	19.5
Tuberculosis and other respiratory diseases	—	0.2	0.2	0.7	1.7	2.1	2.1	7.6
Eye, ear, nose, and throat	1.4	0.7	0.7	0.6	0.4	2.8	6.8	16.0
Orthopedic	—	0.3	1.4	2.7	10.4	17.5	25.1	34.7
Chronic Diseases	—	—	0.1	0.1	0.1	0.3	2.6	1.7
Other	0.5	1.0	1.1	3.2	8.2	13.1	16.6	19.9

SOURCE: American Hospital Association. *Hospital Statistics*, (1979 edition), Chicago, 1979.

Although these protection levels are chosen for expository purposes only, they demonstrate an important point: The ability of hospitals to maintain higher occupancy rates consistent with a specified protection level is greater with larger hospitals, and this is true regardless of the protection level one chooses. This is one of the reasons the average occupancy rates of community hospitals (Table 1) conform to a pattern similar to those in Table 2.

Product diversification

The occupancy rates reported in hospital literature are "overall" occupancy rates. But, as Table 3 shows, the modern hospital is truly a multiproduct firm with as many as 20 distinct patient facilities, several of which may not be substitutable (interchangeable) in the sense that an obstetric patient cannot be placed in a burn care unit and vice versa. It follows that for assessing the occupancy rate of a hospital with several nonsubstitutable facilities, the institution must be regarded as a conglomerate of several mini-hospitals. If we look at it this way, it might turn out that the occupancy rate of a hospital that seems low on an overall basis may not, in fact, be so low when we take into account the number of nonsubstitutable facilities it maintains. To illustrate the point, let us consider the hypothetical example presented in Table 4.

Table 4
Occupancy rates of two hypothetical hospitals, by type of facility

Type of facility	Hospital A		Hospital B	
	Occupancy rate at 98 percent protection level	Occupancy rate at 98 percent protection level	Occupancy rate at 98 percent protection level	Occupancy rate at 98 percent protection level
	Beds	Percent	Beds	Percent
Total beds	100	—	100	—
Overall occupancy rate	—	80	—	61
Medical-surgical	100	80	25	61
Obstetrics	—	—	25	61
Cardiac	—	—	—	—
Intensive care	—	—	25	61
Burn care	—	—	25	61

Although hospitals A and B have the same number of beds, the former with a single facility—medical-surgical—can maintain an overall occupancy rate of 80 percent, whereas the latter with four nonsubstitutable facilities can maintain an overall occupancy rate of only 61 percent. The 98 percent protection level (or a turnaway rate of 1 day in 50) is used for illustrative purpose only; but the example does demonstrate that, having decided upon a certain protection level, hospitals A and B should not be treated equally. The latter deserves consideration for its product diversification if the diversification is warranted by hospital B's role in the health delivery system.

Urgent versus nonurgent admissions

Consider a patient facility that accepts nonurgent (elective) cases. It is possible to maintain this facility at a higher level of occupancy rate for two reasons. First, it is possible to schedule admissions in such a way as to keep idle capacity at a low level. Second, because the consequences of delayed admissions are less life-threatening, the facility can be operated with a lower "safety margin." There is some indirect evidence that points to the conclusion that units that specialize in nonurgent (elective) cases are operating at higher levels of occupancy. For example, the 1981 average occupancy rate of non-Federal, long-term, general hospitals was 86.2 percent (American Hospital Association, 1982); and the 1976 occupancy rate of nursing homes averaged 89.0 percent (Jones and Van Nostrand, 1979). Now, a typical community hospital has a combination of urgent and nonurgent facilities. It is, therefore, reasonable to assume that the ability of a hospital to maintain a certain level of occupancy rate depends also on the relative size of urgent versus nonurgent facilities. If nonurgent facilities constitute a larger proportion of total facilities, the ability of a hospital to maintain a higher level of occupancy rate will be greater.

Regional differences in demand fluctuations

Tables 2 and 4 are based on the simplified assumption that arrivals of patients are governed by a homogeneous Poisson process, that is, a process with constant intensity (Parzen, 1962). It is, however, a fact that superimposed on this patient arrival process, there exists another source of fluctuation—systematic (seasonal) fluctuations (Feldstein, 1979). Some causes and consequences of seasonal fluctuations are discussed here.

First, consider a region that experiences seasonal influx and outflow of people because it is a resort area, vacation spot, or because it relies heavily on seasonal occupations such as agriculture, fishing, lumbering, and so on. The demand for hospital care generated by such a region will, no doubt, exhibit considerable seasonal fluctuations.

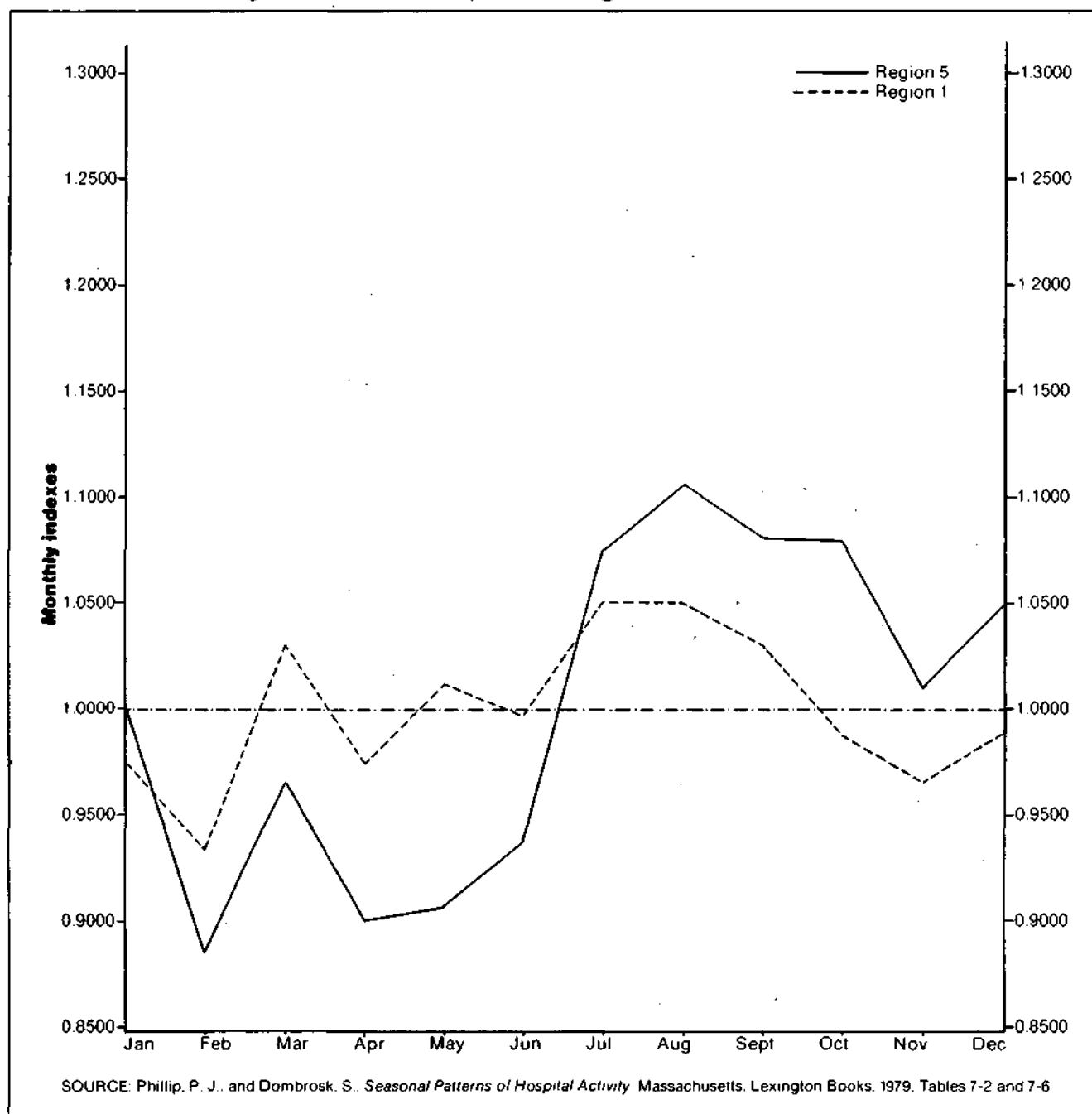
Second, it is well known that arrivals of patients in regions having relatively static populations are also characterized by seasonal fluctuations. Although these fluctuations are of three kinds—hourly, daily, and monthly—by far the most pronounced are of the monthly variety, and they are attributable, in large part, to climatic variations. Because land-locked regions experience more severe climatic variations than coastal, peninsular, and archipelagic regions, there are significant regional differences in the amplitude of fluctuations in arrivals of patients (Phillip and Dombrosk, 1979). Monthly fluctuations in birth-related admissions, on the other hand, tend to increase as we move from the Frigid Zone to the Torrid Zone (Takahashi, 1964). It is significant that according to a study based on the data of 14 years (1963-1976), births and newborn days (the number of days the newborn are in the hospital after birth) exhibit the highest fluctuations in census regions 5 (East South Central), and the lowest in census region 1 (New England). See Figure 1.

Third, the smaller the population base of a service area, the higher is the relative variation in the demand for hospital care generated by that area (Technical Note, Section A). Therefore, hospitals operating in rural areas having very low population density must maintain greater idle capacity to accommodate wider fluctuations in the demand for their services.

Fourth, it can be demonstrated that the lower the admission rate per capita, the higher the relative variation will be in the demand for hospital care, other things being equal (Technical Note, Section A). Although the impact of differential admission rates on demand variations and ultimately on the occupancy rates maintained by hospitals is somewhat obscured by confounding factors such as population size, age-composition, and the number and size of hospitals, some insight can be gained by focusing on extreme situations. For example, according to 1980 statistics, Alaska which has the lowest admission rate (98 per 1,000 people) has an unusually low occupancy rate (58.3 percent); and the District of Columbia which has recorded the highest admission rate (249 per 1,000 people) has an unusually high occupancy rate (84.1 percent) (American Hospital Association, 1981).

Fifth, other things being equal, fluctuations in the demand for hospital services facing any individual hospital will be smaller if a single, large hospital serves the area; fluctuations will be larger if several hospitals, each sharing a small portion of the total demand, serve the area (Technical Note, Section A). Displayed in Table 5 are U.S. census regions arranged in ascending order by number of community hospitals per 1,000 people, and regional occupancy rates.

Figure 1
Monthly indexes of births, census region 1 versus 5: 1963-1976



Although the inverse relationship displayed in Table 5 is far from perfect ($r = -0.68$), one can discern a general tendency toward lower occupancy rates as the number of hospitals per 1,000 people increases. This relationship has an interesting implication for regulators and planners. The demand for hospital care generated by a service area can be met more economically if beds are concentrated in a few large hospitals than if they are dispersed in several small hospitals. This statement is subject to the proviso that considerations of access (which depend on the spatial distribution of population, topography, and transportation), and

economies of scale (which dictate that hospital size does not deviate too far from the optimum) are not materially compromised in the process.

In sum, the amplitude of demand fluctuations facing an individual hospital depends, in part, on the degree of fluctuations in the demand for hospital services generated by that service area and, in part, on the organization of hospital facilities in that area. Since hospital service areas differ along both these dimensions, so do the occupancy rates maintained by hospitals serving the areas.

Table 5
Number of community hospitals
and occupancy rate, by census region: 1980

Census region	Community hospitals Number per 1,000 people	Reported occupancy rate Percent
Middle Atlantic	0.0170	84.5
New England	0.0206	82.1
East North Central	0.0217	78.7
South Atlantic	0.0222	78.1
Pacific	0.0227	72.3
Mountain	0.0323	71.7
East South Central	0.0333	76.9
West South Central	0.0356	72.3
West North Central	0.0465	73.3

SOURCES: American Hospital Association. *Hospital Statistics*. Chicago, 1981. United States Census. *Statistical Abstracts of the United States*, 103d edition, p. 10. Washington, 1982.

Empirical validation

We have discussed several factors that could influence the occupancy rates maintained by community hospitals. These may be expressed in the following functional form:

$$OR = f(S, PD, PNU, RV, H)$$

+ - + - -

where

OR = Overall occupancy rate (average daily census ÷ statistical beds set up and staffed).

S = Hospital size (measured by statistical beds).

PD = Product diversification index. (see below)

PNU = Percent nonurgent beds

RV = Relative variation in the demand for hospital care faced by individual hospitals. (see below)

H = Number of hospitals serving an area.

The hypothesized direction of influence is indicated below each symbol. For example, hospital size (S) increases overall occupancy rate, product diversification (PD) reduces it, and so on.

A thorough-going empirical test of this model requires more comprehensive and more refined data than we currently have. Turning first to the dependent variable, OR, the data used are overall occupancy rates reported by some 4,000 community hospitals for 1980. To be sure, this group includes an unknown percentage of hospitals that did not have time to adjust their bed complements (if, in fact, they wanted to) in response to environmental changes such as the influx or outflow of service area population, the opening or closing of hospitals in the vicinity, the opening of transportation network that effectively expands the service area, and so on. Ideally, these hospitals should have been excluded because they are apt to introduce bias to, and increase the standard errors of the estimated parameters. The entropy measure, generally credited to Theil (1971) in economic lit-

erature, but which goes back much further (Shannon, 1948), is used to construct a Product Diversification Index (PD) for each hospital (Technical Note, Section B). Beds set up in the Nonurgent (Elective) Facilities are expressed as percent of all beds to obtain PNU. The breakdown between Urgent and Nonurgent used is a rather broad, facile one; but data limitations preclude a more refined taxonomy (Technical Note, Section C). Sensitive data on the relative variations in demand facing individual hospitals are hard to come by. Following Chiswick (1976), we have computed rough measures of RV for each Standard Metropolitan Statistical Area (SMSA) and non-SMSA⁴ (Technical Note, Section A). Finally, SMSA's and non-SMSA's are the areal units used to derive H.

With overall occupancy rate (OR) as the dependent variable, and S, PD, PNU, RV, and H as independent variables, a regression analysis was performed on the 1980 data of all community hospitals that furnished information on facilities and utilization. The functional relationship specified took the following form:

$$\log OR = a + b_1 \log S + b_2 \log PD + b_3 \log PNU + b_4 \log RV + b_5 \log H + e$$

The estimated parameters of this model with standard errors in parentheses, are presented in Table 6.

⁴This measure does not reflect the systematic component of demand fluctuations such as those resulting from seasonal influx and outflow of people, and climatic variations.

Table 6
Results of regression analysis
(N = 4,030)

Variable	Regression coefficients (b _i)	Standardized regression coefficients (β _i)	F
Hospital size (S)	0.1219 (0.0038)	0.4867	11,009
Relative variation (RV)	-0.0163 (0.0049)	-0.0476	111
Number of hospitals per 1,000 people (H)	-0.0400 (0.0047)	-0.1373	173
Product diversification index (PD)	-0.0007 (0.0005)	-0.0157	22
Percent nonurgent beds (PNU)	0.0038 (0.0009)	0.0561	119
Constant: 1.4983 Adj. R ² : 0.365			

¹Significant at 99 percent.

²Significant at 90 percent.

Results

Before commenting on the results and their practical significance, a digression on optimum occupancy rate is in order. From a social perspective, the concept of optimum occupancy rates revolves around the issue: How does one strike an acceptable compromise between two objectives—minimization of the probability of delayed/denied admissions, and minimization of the probability of hospital resources being used at inefficient rates (Phillip, 1969). Conceptually, the optimum level is where the social cost of expected delay/denial equals the social cost of idle resources. However, the quantification of these costs is fraught with such difficulties that the best that can be done with current knowledge and data is to ensure safeguards against gross imbalances. It is against this background that the significance of the regression function displayed in Table 6 should be considered.

Turning first to the dependent variable, OR, the data used are observed, overall occupancy rates of some 4,000 hospitals. There is no reason to suppose that these rates are optimum in the sense in which we have used that term. As for the independent variables, their status (that is, whether or not they should be deemed legitimate causes of variation in occupancy rates) is, in large part, determined contextually. For example, size (S) must be considered a legitimate cause in the case of a 20-bed hospital serving a rural community where alternative hospital facilities are nonexistent, whereas it may not be so considered in the case of a cluster of small hospitals operating in close geographic proximity. Similarly, product diversification (PD) must be considered a legitimate cause if similar facilities are not available in reasonable proximity, whereas it may not be so considered if it represents duplication of facilities and services in close proximity. These limitations detract seriously from the usefulness of the regression equation as a standard-setting tool. Nonetheless, the sign of every independent variable is in accordance with hypothesized relationship, and the relative importance of variables (as measured by the standardized regression coefficients), generally speaking, conforms to a priori expectations. This strongly suggests that hospital managers do make some effort to adjust bed complements to reach what they perceive to be acceptable protection levels. To be sure, these efforts may not go far enough, or may be tempered by other factors such as prestige, pressure from physicians, benefactors and the community, lack of reliable information on expected demand, or sheer inertia.

From a practical standpoint, the significance of the regression results is twofold: First, it alerts hospital management about the factors to be considered in deciding upon the location and size of hospital facilities. In this respect, the logarithmic form of the regression function facilitates interpretation of regression coefficients (b_i) as elasticities. For example, a 10-percent increase in hospital size is associated with a 1.2-percent increase in occupancy rate, other things being equal. In addition, the standardized regression

coefficients indicate the relative importance of variables. Hospital size (S) is, by far, the most important variable, followed by H, PNU, RV, and PD, in that order. Second, the regression results sensitize planners and regulators to the need to give thoughtful consideration to these factors in setting occupancy standards. That such a sensitive, flexible approach is necessary to avoid gross imbalances may be illustrated by the following example:

It was mentioned earlier that some 208 California hospitals face penalties because their occupancy rates are below 55 percent. According to the California Department of Health Services, although the standard initially proposed is 55 percent, the State plans to raise the limit. It would be interesting to see how these 208 hospitals would have fared had the model been used as a basis for setting standards. Unfortunately, a full-fledged application is not possible because the California standard is based on *licensed* occupancy rate, whereas the model is based on *staffed* occupancy rate. We have, therefore, gone through the list of 208 hospitals provided in Vaida (1981), and selected 75 hospitals whose licensed occupancy rates are equal to staffed occupancy rates. Table 7 summarizes the results for three standards, 55 percent, 60 percent, and 65 percent.

Table 7
Selected California hospitals whose
predicted occupancy rates are below
standard

Bed size	Number of hospitals tested	Hospitals with predicted rates below three hypothetical standards		
		55 percent	60 percent	65 percent
Total	75	3	11	31
6-24 beds	2	2	2	2
25-49 beds	15	1	5	15
50-99 beds	25	—	4	13
100-199 beds	25	—	—	1
200 beds or more	8	—	—	—

Perhaps the best way to interpret the results in Table 7 is to assume, for the sake of argument, that the occupancy rates predicted by the model do constitute fair standards. Then, we may say that three hospitals will be unjustly penalized under the 55-percent standard, 11 under the 60-percent standard, and 31 under the 65-percent standard. What is striking is the discriminatory impact of these standards across bed-size classes. Both of the hospitals in the 6-24 class are penalized, implying that the 55-percent occupancy rate may be too Draconian a standard for very small hospitals; and all hospitals with 200 beds or more have escaped penalty, implying that the 65-percent occupancy rate may be too liberal for very large hospitals.

From a standard-setting perspective, the inference one may draw from the California example seems clear enough. Although setting optimum occupancy rates for hospitals is a desirable goal, setting a uniform rate for all hospitals is certainly not going to achieve it, given the differences in the circumstances surrounding the operation of individual hospitals. Indeed, the inequities that would result from the application of a uniform rate are so glaring that planners and regulators should give thoughtful consideration to the factors discussed in this article. Some of these factors (number of beds, and percent nonurgent beds) are readily accessible to decision-makers. It is therefore, suggested that as a first step, decision-makers think in terms of stratifying hospitals by bed size and percent of nonurgent beds, and then setting stratum-specific standards. For example, a relatively high-occupancy standard should be set for a stratum containing hospitals with, say, over 1,000 beds and with over 5 percent nonurgent beds, whereas a much lower standard should be set for a stratum containing hospitals with under 50 beds and no nonurgent beds.

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Technical note

Section A

Let PD = Patient Days; LS = Average Length of Stay; r = Admission rate per Capita; and POP = Population. Then, the expected patient days in a region (i.e., a Standard Metropolitan Statistical Area [SMSA] or non-SMSA) is:

$$E[PD] = LS(r)(POP) \quad (1)$$

Using the binomial formula, the variance of patient days may be obtained by:

$$Var[PD] = LS^2(r)(POP)(1 - r) \quad (2)$$

And the coefficient of variation of patient days becomes:

$$CV[PD] = \frac{LS\sqrt{r(POP)(1 - r)}}{LS(r)(POP)} \quad (3)$$

which reduces to:

$$CV[PD] = \sqrt{\frac{1}{POP} \left[\frac{1}{r} - 1 \right]} \quad (4)$$

The implications of formula (4) are worth noting. Consider a service area with $r = 0.20$, and $POP = 100,000$. Then the coefficient of variation of patient days will be

$$CV[PD] = \sqrt{\frac{1}{100000} \left(\frac{1}{0.20} - 1 \right)} = 0.006 \quad (5)$$

Suppose we reduce r to, say, 0.15, leaving POP unchanged. Then, the coefficient of variation of patient days becomes:

$$CV[PD] = \sqrt{\frac{1}{100000} \left(\frac{1}{0.15} - 1 \right)} = 0.008 \quad (6)$$

Thus, other things being equal, the lower the admission rate, r , the higher will be the coefficient of variation of patient days, and conversely.

Again, suppose we reduce POP to, say, 10,000, leaving r unchanged.

Then we will have:

$$CV[PD] = \sqrt{\frac{1}{10000} \left(\frac{1}{0.20} - 1 \right)} = 0.020 \quad (7)$$

Thus, other things being equal, the lower the population base of an area, the higher will be the coefficient of variation of patient days, and conversely.

Suppose two regions have the same admission rate (r) and population base (POP). They differ, however, in terms of the organization of hospital facilities. One region is served by a single, large hospital and the other has several hospitals, say, H hospitals of the same size, each serving $100/H$ percentage of population in that area. Then, the coefficient of variation of patient days facing the single large hospital in the first region will be equal to the values estimated in formulas (5) through (7). In contrast, the coefficient of variation of patient days facing each hospital in the second region, which we will call relative variation (RV), will be:

$$RV[PD] = \sqrt{\frac{1}{\frac{POP}{H}} \left(\frac{1}{r} - 1 \right)} \quad (8)$$

which may be rewritten as:

$$RV[PD] = \sqrt{\frac{H}{POP} \left(\frac{1}{r} - 1 \right)} \quad (9)$$

Comparing (9) with (4), we note that RV will be larger than CV . For example, if there are 5 hospitals of about the same size in a region, and r and POP are as given in formula (5), we will have:

$$RV[PD] = \sqrt{\frac{5}{100000} \left(\frac{1}{0.20} - 1 \right)} = 0.014 \quad (10)$$

which is substantially larger than the value of 0.006 we got in formula (5). Thus, the larger the number of hospitals serving an area, the higher will be the relative variation of patient days faced by each hospital, other things being equal.

To summarize the results:

- If a hospital service area has a small population base and low admission rate, and if in addition, this area is served by several small hospitals, the fluctuations in demand facing each hospital will be rather high.
- If a hospital service area has a large population base and high admission rate, and if in addition, this area is served by one or a very few large hospitals, the fluctuations in demand facing the hospital(s) will be rather low.

Section B

We define a measure of product diversification based on the entropy criterion as:

$$PD = - \sum_{k=1}^n P_k \log_e P_k$$

where P_k is the proportion of beds set up for facility k . Since $\log_e 1$ equals 0, this index will have a value of zero if the hospital has only one facility. The highest value attainable is $\log_e n$, and it happens when a hospital has the largest number of facilities, all of equal size.

Section C

Distinct patient facilities

Urgent (Nonelective)	Nonurgent (elective)
Medical-surgical (adult)	Self-care
Medical-surgical (pediatric)	Long-term skilled nursing
Pediatric intensive care	Other long-term care
Neonatal intensive care	Psychiatric
Cardiac intensive care	Mental retardation
Mixed intensive care	Alcoholism/chemical dependency
Burn care	Tuberculosis and other respiratory diseases
Obstetric	Chronic diseases
Neonatal intermediate care	Other
Eye, ear, nose, and throat	
Orthopedic	

References

- American Hospital Association. *Hospital Statistics*. (1981 Ed.) Chicago.
- American Hospital Association. *Hospital Statistics* (1982 Ed.) Table 5A, Chicago.
- Blumberg, M. S.: Distinct patient facility concept helps predict patient bed needs. *Modern Hospital*, 97:75-81, 1961.

Chiswick, B. R.: "Hospital utilization: An analysis of SMSA differences in occupancy rates, admission rates, and bed rates." *Exploration in Econ Res*, 3, Summer 1976, 326-78.

de Leeuw, F. and Grimm, B. T.: The growth of material capacity and the outlook for its utilization: *Survey of Current Business* 58(9):48-56, Sept. 1978.

Feldstein, P. J.: *Health Care Economics*. New York. John Wiley & Sons, 225, 1979.

Hancock, W. M., Magerlein, D. B., and Storer, R. H.: Parameters affecting hospital occupancy and implications for facility sizing. *Health Serv Res* 13(3):276-89, Fall 1978.

Institute of Medicine: *Controlling the Supply of Hospital Beds, A Policy Statement*. National Academy of Science. Washington, 1976.

Jones, J., and Van Nostrand, J.: The national nursing home survey, 1977 summary of the United States. *Vital and Health Statistics*. Series 13, No. 43. DHHS Pub. No. (PHS) 79-1794. National Center for Health Statistics, Public Health Service. Washington. U.S. Government Printing Office, July 1979.

McClure, W.: *Reducing Excess Hospital Capacity*. Minnesota. Interstudy, 1976. et passim.

New York Times.: "City Urged to Cut 1,000 Hospital Beds." Feb. 18, 1980.

Parzen, E.: *Stochastic Processes*. San Francisco. Holden-Day, Inc., 1962, 25.

Phillip, P. J.: Some considerations involved in determining the optimum size of specialized hospital facilities. *Inquiry* VI, Dec. 1969, 44-48.

Phillip, P. J., and S. Dombroski.: *Seasonal Patterns of Hospital Activity*, Massachusetts. Lexington Books, 1979, pp. 52-57.

Shain, M., and M. I. Roemer.: Hospital costs relate to supply of beds. *Modern Hospital*, 92(4):70-73, 168, Apr., 1959.

Shannon, C. E.: A mathematical theory of communication. *Bell System Technical Journal* 27:379-423, 623-656, 1948.

Shonick, W.: Stochastic model for occupancy-related random variables in general-acute hospitals. *J Amer Stat Assoc* 65:1474-79, 1970.

Takahashi, E.: Seasonal variation of conception and suicide. *Tohoku J Exp Med* 84, Dec. 1964.

Theil, H.: *Principles of econometrics*. New York. Johan Wiley, 1971, 640.

U.S. Department of Health and Human Services. National guidelines for health planning. *Federal Register* 42(185), Sept. 23, 1977.

Vaida, M.: Occupancy standards for Medi-Cal reimbursement. *Insight* 5(22):1-6, Apr. 1981.